INTERNATIONAL BACCALAURÉAT BACHILLERATO IBO BACCALAUREATE INTERNATIONAL INTERNACIONAL

M02/420/H(2)M+

MARKSCHEME

May 2002

CHEMISTRY

Higher Level

Paper 2

13 pages

Subject Details: Chemistry HL Paper 2 Markscheme

General

- Each marking point is usually shown on a separate line or lines.
- Alternative answers are separated by a slash (/) – this means that either answer is acceptable.
- Words underlined are essential for the mark.
- Material in brackets (…) is not needed for the mark.
- The order in which candidates score marks does not matter (unless stated otherwise).
- The use of **OWTTE** in a markscheme (the abbreviation for "or words to that effect") means that if a candidate's answer contains words different to those in the markscheme, but which can be interpreted as having the same meaning, then the mark should be awarded.
- Please remember that many candidates are writing in a second language, and that effective communication is more important than grammatical accuracy.
- In some cases there may be more acceptable ways of scoring marks than the total mark for the question part. In these cases, tick each correct point, and if the total number of ticks is greater than the maximum possible total then write the maximum total followed by **MAX**.
- In some questions an answer to a question part has to be used in later parts. If an error is made in the first part then it should be penalised. However, if the incorrect answer is used correctly in later parts then "follow through" marks can be scored. Show this by writing **ECF** (error carried forward). This situation often occurs in calculations but may do so in other questions.
- Units for quantities should always be given where appropriate. In some cases a mark is available in the markscheme for writing the correct unit. In other cases the markscheme may state that units are to be ignored. Where this is not the case, penalise the omission of units, or the use of incorrect units, once only in the paper, and show this by writing □**1(U)** at the first point at which it occurs.
- Do not penalise candidates for using too many significant figures in answers to calculations, unless the question specifically states the number of significant figures required. If a candidate gives an answer to fewer significant figures than the answer shown in the markscheme, penalise this once only in the paper, and show this by writing □**1(SF)** at the first point at which this occurs.
- If a question specifically asks for the name of a substance, do not award a mark for a correct formula; similarly, if the formula is specifically asked for, do not award a mark for a correct name.
- If a question asks for an equation for a reaction, a balanced symbol equation is usually expected. Do not award a mark for a word equation or an unbalanced equation unless the question specifically asks for this. In some cases, where more complicated equations are to be written, more than one mark may be available for an equation – in these cases follow the instructions in the mark scheme.
- Ignore missing or incorrect state symbols in an equation unless these are specifically asked for in the question.
- Mark positively. Give candidates credit for what they have got correct, rather than penalising them for what they have got wrong.
- If candidates answer a question correctly, but by using a method different from that shown in the markscheme, then award marks; if in doubt consult your Team Leader

SECTION A

1. (a) Sum of ***[1]***
orders / powers of concentration terms (in rate expression) ***[1]***. ***[2]***

(b) (A) 0, with justification ***[1]***;
(B) 2, with justification ***[1]***. ***[2]***
*(If 0 and 2 are stated with no justification, award **[1]**)*

(c) rate $\propto k[\mathrm{B}]^2$ ***[1]***

(d) $k = \dfrac{3.0 \times 10^{-4}}{(2 \times 10^{-3})^2} = 75$ ***[1]*** $\mathrm{mol^{-1}\ dm^3\ min^{-1}}$ ***[1]*** ***[2]***
(Accept l instead of dm^3, min^{-1} is essential. Allow ECF from (c).)

(e) 4 (*Allow ECF. Answer must be consistent with (c).)* ***[1]***

(f) in a phase/state different from that of the reagents ***[1]***;
*(Award **[1]** each for any two of the following:)*
adsorption / absorption ***[1]***;
on active sites / on surface of catalyst ***[1]***;
reactants' bonds weakened/broken ***[1]***;
more favourable orientation ***[1]***;
lowers activation energy/E_a ***[1]***;
provides alternative reaction pathway ***[1]***; ***[3]***

(g) (i) (rate) increases ***[1]***;
(alternative route with) lower E_a ***[1]***. ***[2]***

(ii) (rate) decreases ***[1]***;
fewer molecules with E_a / less frequent or energetic collisions between molecules / lower kinetic energy of molecules ***[1]***. ***[2]***

2. (a) high-speed/high-energy electrons / electron gun ***[1]***
knock electron(s) out of magnesium (atoms) ***[1]***. ***[2]***

(b) acceleration ***[1]***;
electric field / oppositely charged plates ***[1]***;
deflection ***[1]***;
(electro)magnetic field / electromagnet *(do not accept electric field)* ***[1]***.
*(Deduct **[1]** if deflection before acceleration. Accept also collimation **[1]** plus suitable explanation e.g. ions are passed through narrow slits **[1]**.)* ***[4]***

(c) $(24 \times 0.786) + (25 \times 0.101) + (26 \times 0.113)$ ***[1]***
$= 24.327$ (*must be to 3 decimal places*) ***[1]*** ***[2]***

(d) $1s^2\,2s^2\,2p^6\,3s^2$ / [Ne] $3s^2$ ***[1]***

3. (a) Proton / H^+ donors. ***[1]***

(b) (i) hydrochloric acid, greater concentration of ions / *OWTTE* / strong electrolyte / dissociates completely. ***[1]***

(ii) 1 ***[1]***;
> value for HCl < 7 ***[1]***. ***[2]***

(c) $CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$ ***[1]*** ($\rightleftharpoons$ *is essential*)
base acid ***[1]*** ***[2]***

(d) $10^{-pK_a} = 1.74 \times 10^{-5}$ (*ignore units*)
(*minimum 2 sig figs*) ***[1]***

(e) $\dfrac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ (*accept* $[H_3O^+]$ *in the equation*) ***[1]***

(f) $[H^+] = \sqrt{1.74 \times 10^{-5} \times 0.050} = 9.33 \times 10^{-4}$ ($mol\,dm^{-3}$) ***[1]***
$pH = -\log[H^+] = -\log 9.33 \times 10^{-4} = 3.03$ ***[1]*** ***[2]***

4. (a) $CuO + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2O$ ***[1]***

(b) $0.036\ dm^3 \times 1.15\ mol\,dm^{-3} = 0.0414\ mol$ ***[1]***

(c) $0.0414\ mol\ HNO_3 \times \dfrac{1\ mol\ Cu(NO_3)_2}{2\ mol\ HNO_3} = 0.0207\ mol\ Cu(NO_3)_2$ +

$0.0345\ mol\ CuO \times \dfrac{1\ mol\ Cu(NO_3)_2}{1\ mol\ CuO} = 0.0345\ mol\ Cu(NO_3)_2$ +

HNO_3 is limiting reagent (*Must be justified, not guessed. Allow ECF.*) ***[1]***

therefore 0.0207 mol $Cu(NO_3)_2$ formed (*allow ECF*) ***[1]*** ***[2]***

(d) $63.55 + 124.02 + 54.06 = 241.63\ g\,mol^{-1}$ ***[1]***

$241.63\ g\,mol^{-1} \times 0.0207\ mol = 5.00\ g$ *(allow ECF from (c) and from molar mass)****[1]*** ***[2]***

SECTION B

5. (a) **A** contains O—H because 3400 ***[1]***;
B contains C□□O because 1720 ***[1]***;
C contains C□□O and O—H because 1720 and 3100 ***[1]***;
D contains C□□C because 1650 ***[1]***.
(*Accept names e.g. hydroxyl instead of O–H*) ***[4]***

(b) (**A**) butan-**1**-ol / 1-butanol / $CH_3CH_2CH_2CH_2OH$ ***[1]***
(**B**) butanal, $CH_3CH_2CH_2CHO$ ***[1]***
(**C**) butanoic acid, $CH_3CH_2CH_2COOH$ ***[1]***
(**D**) but-1-ene, $CH_3CH_2CHCH_2$ ***[1]*** (*allow butene but not but-2-ene*)
*(Accept answers based on identifying **A** as 2-methylpropan-1-ol)*
*(There are 8 marking points, 4 names and 4 structures. Award marks as follows: 8 correct **[4]**, 6 or 7 correct **[3]**, 4 or 5 correct **[2]**, 2 or 3 correct **[1]**, 0 or 1 correct **[0]**.* ***[4]***

(c) (i) oxidation / redox ***[1]***;
potassium dichromate(VI) / potassium manganate(VII) *(accept formulas)* ***[1]***;
acidified / heat ***[1]***. ***[3]***

(ii) it is more easily oxidised / it is oxidised to compound **C** unless it is removed / *OWTTE* ***[1]***

(d) elimination / dehydration ***[1]***;
(concentrated) sulfuric acid /phosphoric acid / Al_2O_3 / porous pot ***[1]***;
water ***[1]***. ***[3]***

(e) hydrogen / H_2 ***[1]***;
$(2CH_3CH_2CH_2CH_2OH + 2Na) \rightarrow$ **$2CH_3CH_2CH_2CH_2ONa$** $(+ H_2)$ ***[1]***;
$(2CH_3CH_2CH_2COOH + 2Na) \rightarrow$ **$2CH_3CH_2CH_2COONa$** $(+ H_2)$ ***[1]***;
(*Only the correct formula of each product is needed. Accept C_4H_9ONa, etc.*)
sodium butanoate ***[1]***. ***[4]***

(f) **B**, **A**, **C** ***[1]***;
B has dipole–dipole attractions / no hydrogen bonding ***[1]***;
A has hydrogen bonding ***[1]***;
C has more/stronger hydrogen bonding / forms dimers (*difference with **A** must be clear*) ***[1]***.
(Explanation marks can be gained if order is wrong.) ***[4]***

(g) Asymmetric carbon atom / chiral centre / C atom joined to 4 different atoms/groups ***[1]***. ***[2]***
$CH_3CH(OH)CH_2CH_3$ ***[1]***

6. (a) (i) (diagram) electrodes in molten salt ***[1]***;
(diagram) polarities of electrodes and correct products shown ***[1]***;
(diagram) electron flow in wires correctly shown ***[1]***;
$Na^{+} + e^{-} \rightarrow Na$ ***[1]***;
$2Cl^{-} \rightarrow Cl_2 + 2e^{-}$ / $2Cl^{-} - 2e^{-} \rightarrow Cl_2$ ***[1]***. ***[5]***

(ii) hydrogen ***[1]***;
hydrogen ions are more easily discharged than sodium ions ***[1]***;
because of position in reactivity series / *OWTTE* ***[1]***.
(For last two points, accept correct reasoning based on E^{O} values.)
Or
oxygen ***[1]***;
when Cl^{-} concentration is low ***[1]***;
reference to difference in electrode potentials ***[1]***. ***[3]***

(iii) electrons $n = \frac{5 \times 60 \times 60}{96\,480} = 0.187$ mol;
(*First two marks for method*, *5 × 60 × 60* ***[1]*** *and 96480* ***[1]***)
mass of sodium $= (0.187 \times 22.99) = 4.29$ - 4.30 g *(accept 4 g)* ***[1]***; ***[3]***

(b) (i) $C_2O_4^{2-} \rightarrow 2CO_2 + 2e^{-}$ (*do not accept C_2O_4*) ***[1]***;
(in ethanedioate) **+3** ***[1]***;
(in carbon dioxide) **+4** ***[1]***;
(+ sign needed for oxidation number, if omitted penalise once. If 3+ and 4+ stated, award 1 mark out of 2.)
carbon's oxidation number increases / becomes more positive / electrons are lost ***[1]***. ***[4]***

(ii) $Cr_2O_7^{2-} + 14H^{+} + 3C_2O_4^{2-} \rightarrow 2Cr^{3+} + 7H_2O + 6CO_2$
all formulas correct ***[1]***;
correctly balanced ***[1]***. ***[2]***

(c) (i) temperature 25 °C / 298 K ***[1]***;
concentration 1 mol dm^{-3} ***[1]***. ***[2]***

(ii) (*Any two of the following*. *Accept appropriate diagram*.)
salt bridge ***[1]***;
containing *e.g.* aqueous potassium nitrate/chloride ***[1]***.
external circuit / voltmeter ***[1]***; ***[2]***

(iii) $E^{O} = 0.80 - (-0.23) = 1.03$ V *(+ sign, − sign, or no sign is acceptable)* ***[1]***;
$Ni(s) / Ni^{2+}(aq) \,\|\, Ag^{+}(aq) / Ag(s)$ species in correct order ***[1]***;
(*or reversed*)
all state symbols correct ***[1]***.

$Ni + 2Ag^{+} \rightarrow Ni^{2+} + 2Ag$ ***[1]*** ***[4]***

7. (a) (i) (IE decrease) electron removed is further from nucleus ***[1]***;
electron shells have higher energy / repelled by more complete electron shells / less attraction / less effective nuclear charge / *OWTTE* ***[1]***;

(mp decrease) weaker attraction between ions and free electrons ***[1]***;
as nucleus shielded by more electron shells / *OWTTE* ***[1]***. ***[4]***

(ii) $2Li + 2H_2O \rightarrow 2LiOH + H_2$ ***[1]***;
e.g. lithium floats / moves around ***[1]***;
bubbles / fizzes / exothermic / heat produced ***[1]***;
(potassium) fire / flame / more vigorous / *OWTTE* ***[1]***. ***[4]***

(iii) reactivity increases down the group ***[1]***;

*(Award **[1]** each for any two of the following:)*
outer electron more easily lost / ionisation energy decreases down the group ***[1]***;
outer electron more shielded ***[1]***;
<u>outer</u> electron further from nucleus / *OWTTE* ***[1]***. ***[3]***

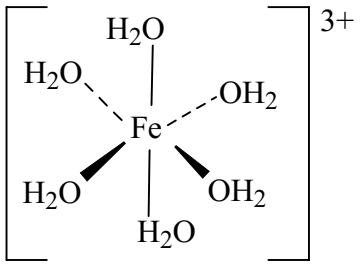
(b) (i) *(Award **[1]** each for any three of the following:)*
attraction of ions and electrons increases ***[1]***;
magnesium ions are more positive than sodium ions ***[1]***;
and release twice as many electrons ***[1]***;
magnesium ion smaller than sodium ion ***[1]***.
*(greater charge density scores **[2]**)* ***[3]***

(ii) covalent bonds throughout the structure / macromolecular / *OWTTE* ***[1]***;
need much energy to break / *OWTTE* ***[1]***. ***[2]***

(iii) exist as small/separate/discrete molecules ***[1]***;
(weaker) van der Waals' forces / intermolecular forces between them ***[1]***. ***[2]***

(iv) its molecule is larger / has higher M_r / S_8 / more electrons / stronger van der Waals' forces ***[1]***

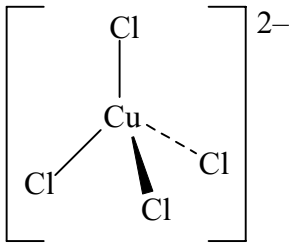
(c) (i) $[Fe(H_2O)_6]^{3+}$ ***[1]***;
octahedral / suitable diagram



[1].

[2]

(ii) $[CuCl_4]^{2-}$ ***[1]***;
tetrahedral / suitable diagram



[1].

[2]

(iii) $[Ag(NH_3)_2]^+$ ***[1]***;
linear / straight line / suitable diagram
$[H_3N—Ag—NH_3]^+$ ***[1]***.
(*Allow ECF from formula to shape in each case*)

[2]

8. (a) (i)

(diamond)	macromolecular / covalent bonds throughout ***[1]***;
hard	atoms held strongly in position ***[1]***;
insulator	no free electrons / all outer electrons used in localized bonding / *OWTTE* ***[1]***;
(graphite)	layers or sheets of atoms ***[1]***;
soft	weakly attracted to each other / *OWTTE* ***[1]***;
conductor	(one) outer electron free/delocalised ***[1]***.

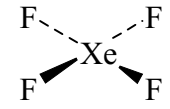
[6]

(1st and 4th marks could be scored on diagrams).

(ii) (within the molecule) covalent / shared pair of outer electrons / diagram ***[1]***;
(between molecules) van der Waals' / attraction between temporary dipoles ***[1]***. ***[2]***

(iii) ions in crystal lattice / in fixed positions ***[1]***;
become free to move when molten ***[1]***. ***[2]***

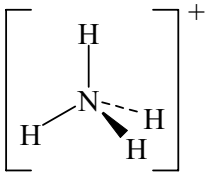
(b) (i)



[1];

square planar (*allow octahedral if lone pairs shown*) ***[1]***. ***[2]***

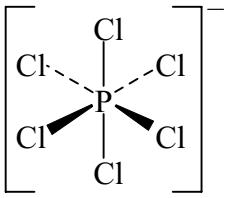
(ii)



[1];

tetrahedral ***[1]***. ***[2]***

(iii)



[1];

octahedral ***[1]***. ***[2]***

(Charges in (b) (ii) and (iii) are not needed to score the mark)
(Shapes drawn need to be recognisable. In each case allow ECF from shape drawn to name of shape. Credit can be given independently for correct name of shape.)

(c) (i)

(hybridisation)	mixing of atomic orbitals/s and p orbitals ***[1]***;
	to form new orbital with character of both / *OWTTE* ***[1]***;
(sigma bonding)	orbitals overlap end-on ***[1]***;
	electrons between nuclei ***[1]***;
(ethane)	sp^3 ***[1]***.

(*both marks for sigma bonding can be achieved by a suitable diagram*) ***[5]***

(ii) (pi bonding) overlapping orbitals are parallel to each other ***[1]***;
electrons above and below nuclei / *OWTTE* ***[1]***;
(ethene) sp^2 ***[1]***;
(ethyne) sp ***[1]***.
(*both marks for pi bonding can be achieved by a suitable diagram*) ***[4]***